ABC of resuscitation
Near drowning

Mark Harries

At times, cold can protect life as well as endanger it. There have been extraordinary examples of survival after long periods of submersion in ice cold water. Such cases highlight the differences in the approach to resuscitation that sets the management of people who nearly drown apart from all other circumstances in which cardiopulmonary arrest has occurred.

This article is adapted from the 5th edition of the *ABC of Resuscitation*, which will published by BMJ Books in December (www.bmjbooks.com)

Case history

A fit young woman was cross country skiing with friends when she fell down a water filled gully and became trapped beneath an ice sheet. Frantic efforts were made to extract her, but after 40 minutes all movements ceased. Her body was eventually recovered, one hour and 19 minutes later, through a hole cut in the ice downstream. She was pronounced dead at the scene, but was given cardiopulmonary resuscitation throughout the air ambulance flight back to hospital, where her rectal temperature was recorded as 13.7°C. Her body was rewarmed by means of an extracorporeal membrane oxygenator. After 35 days on a ventilator and a further five months of rehabilitation, she was able to resume her job as a hospital doctor.

Management at the scene

Rewarming

Attempts to rewarm patients with deep hypothermia outside hospital are inappropriate, but measures to prevent further heat loss are important. Good evidence suggests that when cardiac arrest has occurred, chest compression alone is as effective as chest compression with expired air resuscitation. Extracorporeal rewarming plays such an important part that unconscious patients with deep hypothermia should not be transported to a hospital that lacks these facilities.

To prevent further heat loss in conscious patients with hypothermia, wet clothing should be removed before they are wrapped in thick blankets. Hot drinks do not help and should be avoided. Shivering is a good prognostic sign. Attempts to measure core temperature at the scene are pointless.

Collapse after removal from water

It requires at least two adults to lift a person from the water into a boat. Head-out upright immersion in water at body temperature results in a 32-66% increase in cardiac output because of the pressure of the surrounding water. Resistance to circulation is suddenly removed as the person leaves the water, which, when added to venous pooling, can cause circulatory collapse. This is believed to be the cause of death in many individuals found conscious in cold water but who perish within minutes of rescue. To counter this effect, patients should be lifted out of the water in the prone position.

Associated injuries

Patients recovered from shallow water, particularly those with head injuries, often have an associated fracture or dislocation of the cervical spine. Those that have entered the water from a height may also have intra-abdominal, thoracic, and spinal injuries.

Resuscitation

Circulatory arrest should be managed in a unit in which facilities are available for bypass and extracorporeal rewarming. This will determine the target hospital. Although patients can be intubated at the scene if required, practical difficulties mean that venous or arterial canulation is better left until arrival in hospital. Continuous chest compression should be applied without rewarming throughout transportation.

The role of procedures that are intended to drain water from the lungs and airways is controversial. Placing the patient's head down in the lateral position probably recovers water from only the stomach. Aspiration of gastric contents is a constant hazard and is one of the reasons for attempting to intubate unconscious patients at an early stage.

Essential factors concerning immersion incidents

Factor	Implications
Length of time submerged	Favourable outcome associated with submersion for <5 min
Quality of immediate resuscitation	Favourable outcome if heart beat can be restored at once
Temperature of the water	Favourable outcome associated with immersion in ice cold water (<5°C), especially infants
Shallow water	Consider fracture or dislocation of cervical spine
A buoyancy aid being used by the casualty	Likely to be profoundly hypothermic. The patient may not have aspirated water. Take precautions to prevent collapse after removal from water
Nature of the water (fresh or salt)	Ventilation/perfusion mismatch from fresh water inhalation more difficult to correct. Risk of infection from river water high. Consider leptospirosis

Whatever the method of rescue, patients should be lifted out of the water in the prone position

Hypothermia may render the carotid pulse impalpable, but it is important not to start chest compression without evidence of cardiac arrest. Unnecessary compressions can induce ventricular fibrillation in a patient whose circulation, although sluggish, is otherwise intact. Electrocardiographic monitoring should be available. Defibrillation is ineffective if the myocardium is cold, and there are obvious safety concerns when giving an electric charge in or around water. The bucking action of inshore rescue boats makes expired air ventilation hazardous.

Resuscitation on scene

- Chest compression alone for circulatory arrest
- No rewarming for deep hypothermia
- Intubate unconscious patients
- Defibrillation is unlikely to succeed
- Associated trauma may include fracture of the cervical spine

Management in hospital

Decision to admit

The decision to admit depends on whether water has been aspirated because it is this that places the patient at risk from pulmonary oedema. Haemoptysis, lung crackles, fluffy shadows on the chest radiograph, and hypoxia when breathing air are all signs of aspiration and are indications for hospital admission. If pulmonary oedema develops, it usually does so within four hours. Therefore, if after four hours the patient remains free of symptoms he or she may be discharged home safely.

Pulmonary oedema and positive end expiratory pressure

A low reading thermometer with a rectal probe inserted at least 10 cm is often used to measure the patient's core temperature. Devices that measure the temperature of the tympanic membrane are a satisfactory alternative, provided that the patient's temperature is within the range of the device used.

If the patient has a low core temperature, a correction factor is required to calculate the true arterial blood oxygen saturation. A falling arterial oxygen pressure is a sign of impending respiratory distress syndrome (normal atrial pressure pulmonary oedema) and an indication for assisted ventilation with positive end expiratory pressure. The ideal pressure setting for positive end expiratory pressure is that which maintains the arterial oxygen pressure above 10 kPa with an inspired oxygen fraction below 0.6.

Evidence suggests that aspirated fresh water is more likely than seawater to produce pulmonary oedema. Systemic steroids have no effect on outcome and offer no advantage.

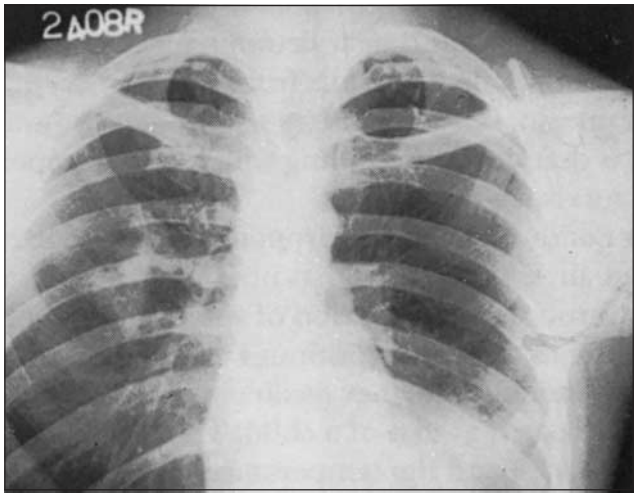
Rewarming

Extracorporeal membrane oxygenation with extracorporeal warming is the gold standard treatment for patients with profound hypothermia. The Swiss Mountain Rescue Service has recovered the bodies of 46 individuals over the years, all with deep hypothermia from burial in snow. Fifteen out of 32 treated with extracorporeal rewarming survived. Conscious patients can be placed in a bath maintained at a temperature of 40°C.

Fluid and electrolyte balance

Plasma electrolyte differences between patients who aspire fresh water and seawater are seldom clinically important. In both situations, the patient is often hypovolaemic and in need of intravenous fluid replacement, preferably with a crystalloid solution.

Metabolic acidosis should be corrected by adequate oxygenation and plasma expansion; administration of sodium bicarbonate should be unnecessary. Water intoxication resulting in fits has been reported in infants after near drowning in backyard pools.



Shadowing in the left zone and right mid-zone represents aspirated water. The patient is at risk of developing adult respiratory distress syndrome

Treating hypothermia in hospital

- Rewarm in bath water at 40°C
- Remove wet clothing if patient can be sheltered
- Actively rewarm with extracorporeal bypass if necessary

Essential early measures

Intervention	Comment
Tracheal intubation for regurgitation	Secures the airway in the event of unconscious patients
Electrocardiography	Pulseless patient may have bradyarrhythmias or ventricular fibrillation
Nasogastric tube	Decompresses the stomach thereby assisting ventilation. Reduces the risk of regurgitation
Rectal temperature	Use low reading thermometer. Insert the probe at least 10 cm
Arterial blood gases	Low arterial oxygen pressure breathing air is a marker for pulmonary oedema or atelectasis with shunting. pH $<$ 7 is associated with poor prognosis
Chest radiography	Shows aspirated fluid. Early indication of pulmonary oedema
Central venous line	Essential for monitoring level of positive end-expiratory pressure respiration
Culture blood for both aerobic and anaerobic organisms	Septicaemia common. Consider exotic organisms. Brain abscess is a late complication

Infection
Lung infection is common after near drowning, especially if brackish water has been aspirated. Embolism of infected material from the lungs to the arterial tree may result in brain abscesses or death from systemic aspergillosis. Blood should be cultured from all patients who have aspirated water. Leptospirosis has been reported after immersion in lakes or reservoirs, possibly due to ingestion of water contaminated with rats' urine. Outpatient follow up with a chest radiography after two weeks is advisable for all patients who have been immersed in water, irrespective of their clinical state on admission.

Prognostic signs
A blood pH ≤7 indicates severe acidosis and is a poor prognostic sign. A low arterial oxygen pressure provides an early indication that water has been inhaled with the attendant risk of pulmonary oedema. The presence of ventricular fibrillation is an adverse sign and responds poorly to defibrillation when the core temperature is below 28°C. The circulation must be supported by chest compression until further attempts can be made when the core temperature has been raised above this level.

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Further reading

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Q&A

Saving expressed breast milk

Question
How long does expressed breast milk last? Should it be kept in a refrigerator?

Priyankara C D Atapattu *registered medical officer, Walasmulla, Sri Lanka*

Answer
The Breastfeeding Network (BfN) recently investigated this issue (Hands A. Safe storage of expressed breast milk in the home. *MIDIRS Midwifery Digest*, 2003;13:378-85).

> "Current guidelines for the safe storage of expressed breast milk (EBM) were found to be inconsistent and confusing, ranging from 24 hours to 8 days in the fridge. Primary research showed EBM could delay bacterial growth, keeping it safer for longer than processed milk. Freezing affects these antibacterial properties.
>
> Careful handling during collection and accurate storage temperature is stressed to prevent bacterial contamination and minimise bacterial growth. Studies showed EBM to be safe for up to 8 days below 4°C and up to 3 days at 4-10°C. It has not been shown if milk is safe (or unsafe) at either refrigeration temperature. There is evidence to suggest that contaminated milk is safer stored at 4°C for 8 days than frozen; and that previously frozen breast milk should be kept for as short a time as possible before use."

Anabel H Hands *former dairy microbiologist and BfN trustee, Paisley*

Answer
The following guidance is taken from *Guidelines for the Collection, Storage and Handling of Breastmilk for a Mother's Own Baby in Hospital*, published by the UK Association for Milk Banking, 2nd edition, 2001. As it is intended for use with babies who have been born preterm or are unwell, it incorporates a margin of safety. The storage times are therefore less generous than those sometimes used for well babies at home.

> "Breastmilk should be kept at room temperature for as short a time as possible and refrigerated immediately after expression. If a mother is expressing at home and has no access to a fridge, the milk can be kept at room temperature for up to 6 hours. If milk is to be used within 48 hours it should be stored in a refrigerator at a temperature of 2-4°C. Milk which has not been used after 48 hours should be stored frozen (−20°C) for a maximum of 3 months if it is to be fed to sick preterm infants."

Gillian A Weaver *chair of United Kingdom Association for Milk Banking, Queen Charlotte's and Chelsea Hospital, London*

Answer
Searching the web using Google and the phrase "storing expressed breast milk" gives a good set of results. Quality of information is obviously an issue; however, a quick scan shows that there seems to be a degree of consistency among the guidelines and some are published by well respected organisations. See www.ich.ucl.ac.uk/factsheets/misc/breastfeeding_and_expressing/

John C Platt *senior nurse lecturer, Northern General Hospital, Sheffield*

http://bmj.com/cgi/qa-display/short/bmj_el;37683

These exchanges were posted on the Q&A section of bmj.com. If you want to respond to the question, or ask a new question of your own, follow the link above or go to http://bmj.com/q&a